

Lesson Plan

Simulating the Greenhouse Effect in a Terrarium.

Content Standards:

1. Matter and Energy in the Earth System

Central Concepts

- 1.1 Identify Earth's principal sources of internal and external energy, such as radioactive decay, gravity, and solar energy.
- 1.3 Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes
 - o making observations
 - o making and recording measurements at appropriate levels of precision
 - o collecting data or evidence in an organized way
- Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage.
- Follow safety guidelines.

Scientific Inquiry Skills Standards

High School

- SIS1. Make observations, raise questions, and formulate hypotheses.
 - Observe the world from a scientific perspective.
- SIS2. Design and conduct scientific investigations.
 - Employ appropriate methods for accurately and consistently
 - o making observations
 - o making and recording measurements at appropriate levels of precision
 - o collecting data or evidence in an organized way
- SIS4. Communicate and apply the results of scientific investigations.
 - Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology (e.g., presentation software) and other tools to present findings.

Day Before the Lesson:

- Reserve the science computer lab or mobile computer lab. (80 min)
- Have students research, view, and take notes on these quick videos:
 - o Global Warming and the Greenhouse Effect
 - o Snapshot of US Energy Use
 - o The Physics of the Greenhouse Effect
 - o The Greenhouse Effect: Is it all Bad?
 - o Earth Systems: Ice and Global Warming, Quick Video
 - o Earth's Albedo and Global Warming, Interactive
- Complete National Geographic resource readings and interactives:
 - o Introduction
 - o It starts with the sun
 - o Greenhouse effect
 - o Greenhouse gases
 - o Explore more, causes, effects, quiz

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Pre-lab Resources for the day before

The Greenhouse Effect, Resource readings and interactives.

<http://environment.nationalgeographic.com/environment/global-warming/gw-overview-interactive.html>

Global Warming and the Greenhouse Effect, Quick Video

http://www.teachersdomain.org/asset/tdc02_vid_greenhouse/

The Physics of the Greenhouse Effect, Quick Video

http://www.teachersdomain.org/asset/phy03_vid_greenhouse2/

Snapshot of Energy Use, Quick Video,

http://www.teachersdomain.org/asset/tdc02_vid_energyuse/

Earth Systems: Ice and Global Warming, Quick Video

http://www.teachersdomain.org/asset/ess05_vid_esglaciers/

Earth's Albedo and Global Warming, Interactive

http://www.teachersdomain.org/assets/wgbh/ipy07/ipy07_int_albedo/ipy07_int_albedo.html

The Greenhouse Effect: Is it all bad? Quick Video,

<http://video.google.com/videoplay?docid=5128613033824536021>

Problem

What causes the Greenhouse Effect and Global Warming?

Background:

'Greenhouse effect' was a term first used to explain about naturally occurring gases in the atmosphere and their function in maintaining habitable temperatures on earth. Over time scientists became concerned with climate change and linked negative aspects of global warming to changes in greenhouse gases. As global climate change became more evident, these negative aspects of accumulating greenhouse gases became associated with what scientists call an enhanced greenhouse effect. While the greenhouse effect makes life possible on earth, it is also strongly influenced by not only the amount and type of gases in the atmosphere but also other factors. Those factors involve what sunlight first encounters when it reaches the earth's surface. Desert sand, beaches, glaciers, forests, dark soil, asphalt, cities, oceans and grasslands all absorb, reflect and radiate solar radiation differently. Sunlight hitting the surface of a white glacier will more readily reflect light back into space, while sunlight falling on dark soil or black asphalt of cities is strongly absorbed as heat by the lower atmosphere.

In this experiment you will find that air over the open containers is constantly changing, and as it gets warm it is more easily replaced by cooler air. The air in the covered bottle is trapped and cannot circulate with air in the rest of the room. If this air stays in the sunlight, it will get warmer, faster and cool slower. Similar trapping of heat occurs in the Earth's atmosphere as a result of the greenhouse effect. Sunlight passes through the atmosphere

and warms the Earth's surface. The heat radiates from the surface at different rates and is trapped by greenhouse gases. Without an atmosphere, the Earth's temperature would be uninhabitable for life, as we know it. This warming due to heat-trapping gases is called the "Greenhouse Effect." In this lab, the uncovered jars and the covered jars allow light to enter, but one is more effective in trapping the energy from sunlight as heat. Each works differently, based on the albedo, or the reflective capability of the surface, and whether the container is covered or uncovered.

Lesson Plan Objectives:

- Help students understand the greenhouse effect as a physical phenomenon.
- Identify factors that effect global warming.
- Use the terrarium setup to examine the effect of temperature, heat absorption and reflection on the atmosphere over land and glacial ice and its effect on global warming.
- Demonstrate by experimentation how the glass covered terrarium simulates an enhanced layer of greenhouse gases.
- Demonstrate, by modeling and experimentation, techniques for observing, recording and analyzing data to form conclusions.

Method of Implementation:

- This lesson is presented as a small group experiment using clear, two liter soda bottles as mini terrariums. The instructor will assign small groups (3 or 4 per group). (60 min)

Alternate Method of Implementation:

- This lesson can also be conducted as a classroom activity by using four aquariums set up similarly. The instructor can insure student involvement and data collection by assigning small groups to collect data for each aquarium. Data can be collected and recorded on the board and shared with classmates for further analyzing and graphing.

Formulating a hypothesis:

- a. Hypothesis about the ability of soil and glacial ice to absorb and release heat during the day.
- b. Hypothesize about how the air above the soil and glacier ice differ during the day from the covered and uncovered containers.

Vocabulary:

➤ **Albedo**

The percentage of solar energy reflected back by a surface

➤ **Atmosphere**

The air that surrounds the earth.

➤ **Carbon Dioxide**

A heavy colorless gas that does not support combustion. It is formed naturally by the combustion and decomposition of organic substances such as fossil fuels and is absorbed by photosynthesis of plants.

➤ **Fossil Fuels**

Fuels that are formed in the earth from plant or animal remains. Examples are coal, oil, and natural gas.

➤ **Global Warming**

The result of the greenhouse effect. It is the warming of the planet's atmosphere.

Natural global warming is a result of the natural greenhouse effect and is what makes the planet hospitable to life. Sometimes, "global warming" is used to mean "the greenhouse effect." That is, sometimes it is used to refer to the warming that is a result of the enhanced greenhouse effect.

➤ **Greenhouse Effect**

The cause of global warming. It is the actual process of greenhouse gases absorbing heat in the atmosphere. There is a natural greenhouse effect that the planet needs to support life. We amplify or enhance the natural greenhouse effect when we load the atmosphere with an excess of greenhouse gases. Usually, the term "greenhouse effect" is used to refer only to the amplified greenhouse effect and not to the natural greenhouse effect.

➤ **Greenhouse Gases**

Greenhouse gases include carbon dioxide, methane, and chlorofluorocarbons, which are released into the atmosphere by burning fossil fuels. These gases build up an effect, creating a blanket that traps additional heat in the earth's atmosphere.

➤ **Solar Radiation**

Sunlight

➤ **Ultraviolet Rays**

Are part of the electromagnetic spectrum, generated by the sun as light waves that cause sunburn and other detrimental effects on humans

➤ **Infrared Rays**

Is part of the electromagnetic spectrum, generated by the sun and known and felt by us as heat from the sun.

➤ **Climate**

Climate is determined over a long period of time by monitoring temperature and precipitation

Materials:

- 4 Mini Terrariums (2 liter, clear bottles) for each group, or Aquariums
- potting soil
- water
- clear plastic wrap
- crushed white Styrofoam or perlite
- 8 thermometers
- ring Stand
- overhead light with reflector (or natural sunlight)
- masking tape
- string
- scissors

Procedures:

Setup 4 clear plastic two-liter soda bottles (mini terrariums) as follows.

1. Cut the top off two of the bottles.

2. Fill two terrariums, with 5" of potting soil. One bottle with the top cut off and one not cut.
3. Fill two terrariums with 5" of water. One bottle with the top cut off and one not cut.
4. Put crushed white Styrofoam into the bottles with water. Put enough in to completely cover the surface of the water (about an 1" thick).
5. Place a thermometer in each open terrarium and secure with masking tape against the inside wall of the open terrarium just above the soil or Styrofoam (water) for easy viewing. Be sure the soil or Styrofoam does not touch the thermometer. Place another thermometer against the inside of each terrarium, 3 inches below the surface of the soil or water for easy viewing with masking tape. This will enable you to easily obtain temperature measurements without disturbing the setup.
6. Place a thermometer in each of the closed bottles by hanging the thermometer from a string just above the soil and Styrofoam. Make sure to put the cap back on the bottle to hold the thermometer in place.
7. Setup a ring stand beside each terrarium to mount an overhead light reflector above the terrarium. Adjust the light source so that each is the same distance above the terrarium.
8. With the light off, record the starting temperatures of each.
9. After recording the starting temperature of each thermometer in the data table, record the temperature of each thermometer every minute for 15 minutes with the light on.
10. Then, turn the light off and repeat by recording the temperature of each thermometer again every minute for 15 minutes.
11. Create a combined line graph of the results of your experiment. Use colored pencils and standardized graphing techniques.
12. Analyze your results.

Going Further:

Students can take the topic of the Greenhouse Effect and Global Warming further by assigning your students to research the affect of Global warming on various topics and parts of the world. These topics can be used for stimulating debate and discussion for further understanding.

Here are a few examples for further research and discussion:

- What affect does Global Warming have on the opening of new shipping routes through the Artic?
- What is the effect of Global Warming on Polar Bears?
- What is the effect Global Warming on Cape Cod and the Massachusetts coastline?
- What is the affect on the state of Florida?
- What effect will Global Warming have on migrating Caribou?
- What affect will Global Warming have on the glaciers of Mt. Kilaminjaro and water supplies?

Assessment

Graphs/Charts/student handouts that go along with the lesson plan.

- Open discussion of the impact of the Greenhouse Effect and Global Warming
- The Greenhouse Effect – Student Worksheet

- Temperature Data Sheet – For recording observations
- Students complete: Your Carbon Diet, Interactive
<http://www.pbs.org/wgbh/warming/carbon/playalready.html>
- End of unit Test – Greenhouse Effect and Global Warming

References:

Prentice-Hall, Exploring Earth Science, The Greenhouse Effect, Englewood Cliffs, NJ, 1995

Merrill, Earth Science, The Heat's On, Glencoe Pub. Westerville, Ohio, 1995

http://www.ucar.edu/learn/1_3_1.htm

http://images.google.com/imgres?imgurl=http://www.pewclimate.org/docUploads/images/greenhouse-effect_012907_085209.gif&imgrefurl=http://www.pewclimate.org/global-warming-basics/facts_and_figures/climate_science_basics/ghe.cfm&usq=__avbPZkA1EVORx3kLt1pX2oacFvM=&h=493&w=490&sz=53&hl=en&start=19&um=1&tbnid=7Cw9v5r72RuTcM:&tbnh=130&tbnw=129&prev=/images%3Fq%3Dgreenhouse%2Beffect%26um%3D1%26hl%3Den%26sa%3DN

<http://www.global-greenhouse-warming.com/>

Data Table for Observations

Time/Min	Temperature of the air above the soil	Temperature of the soil 3" below surface	Temperature of the air above the water	Temperature of the water 3" below surface
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

The Greenhouse Effect - Student Worksheet

Hypothesis:

a)

b)

Draw a diagram of your mini terrarium and label incoming sunlight and the effect of the sunlight on the mini terrarium.

Draw and label a diagram showing how heat that enters the atmosphere is reflected, absorbed, and warms the atmosphere.

Answer the following questions. Use a separate sheet of paper if required.

1. Does the color of the surface affect air temperature in the terrariums? How?
2. Compare the air temperatures in the open terrariums. Which heated up faster and explain why?
3. Compare air temperatures in the closed terrariums. What do your observations indicate?
4. Which of the thermometers indicated the greatest increase in temperature? Explain why?
5. Which of the thermometers indicated the greatest decrease in temperature? Explain why?
6. What part of the atmosphere does the top of the enclosed terrariums represent in our atmosphere?
7. Explain how you think a cloudy night will affect overnight temperatures?
8. Explain how you think a clear night will affect overnight temperatures?

9. How did the covered terrariums affect temperatures inside the terrariums in relation to the uncovered?

10. What is a greenhouse and how does it work?

11. How is the earth's atmosphere similar to a greenhouse?

The Greenhouse Effect and Global Warming

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

- _____ 1. The condition in which air warms and becomes trapped in our atmosphere is called
 - a. a temperature inversion.
 - b. the greenhouse effect
 - c. the ozone layer
 - d. all of the above
- _____ 2. Gases responsible for increasing temperatures in the atmosphere are
 - a. car exhaust fumes.
 - b. CFCs.
 - c. carbon dioxide
 - d. all of the above
- _____ 3. Heat is trapped near Earth's surface by
 - a. the greenhouse effect.
 - b. the ozone layer.
 - c. smog.
 - d. radon.
- _____ 4. Increased amounts of carbon dioxide in Earth's atmosphere may lead to
 - a. more photochemical smog.
 - b. global warming.
 - c. a hole in the ozone layer.
 - d. less of a greenhouse effect.
- _____ 5. The ozone layer is located
 - a. close to Earth's surface.
 - b. in the lower atmosphere.
 - c. in the upper atmosphere.
 - d. in outer space.
- _____ 6. How can people help reduce the emissions that contribute to smog and the greenhouse effect?
 - a. By purchasing products that contain CFCs
 - b. By never pouring chemicals down the drain
 - c. By taking public transportation or walking instead of driving a car
 - d. By finding substitutes for garden chemicals
- _____ 7. Which of the following is an advantage of solar energy?
 - a. It will not run out for billions of years.
 - b. It is not available at night.
 - c. No backup energy sources are needed.
 - d. It must be collected from a huge area.
- _____ 8. What is solar energy?
 - a. energy from water
 - b. energy from the sun
 - c. energy from wind
 - d. energy from fossil fuels
- _____ 9. Solar Energy
 - a. is absorbed by glacial ice
 - b. is reflected by glacial ice
 - c. has no impact on the air temperature above glacial ice
 - d. only affects land masses
- _____ 10. Covered terrariums tend to

- a. let heat escape
 - b. trap heat
 - c. have no effect on temperatures
 - d. have a cooling effect
- ____ 11. Temperatures over forested and soil covered land masses tend to be warmer because
- a. darker surfaces absorb heat
 - b. land masses have more surface area
 - c. global warming affects those areas most
 - d. none of the above

Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

- ____ 12. According to the theory of global warming, the decrease in carbon dioxide is causing Earth's temperature to rise. _____
- ____ 13. The greenhouse effect is due to the increase of carbon dioxide in the oceans. _____

Completion

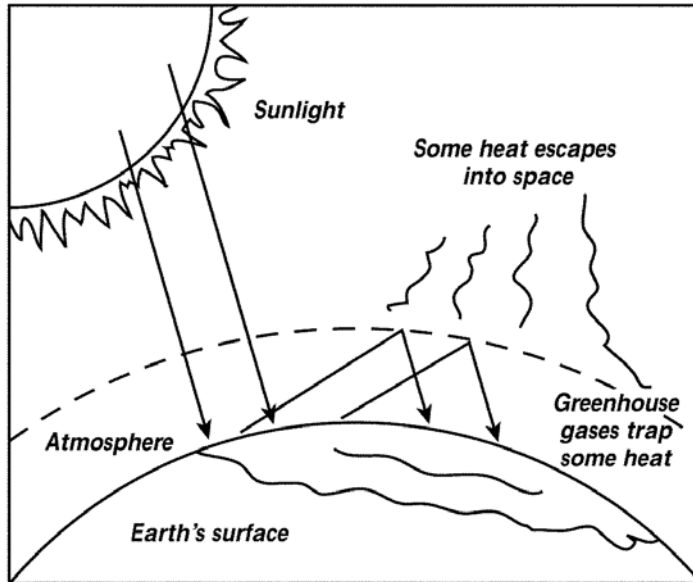
Complete each sentence or statement.

14. The ozone layer is important because it helps to screen out harmful _____ radiation.
15. Water vapor and carbon dioxide cause the _____, the trapping of heat near Earth's surface.
16. Most scientists base their climate predictions on _____ that help them calculate the effects of changes in the atmosphere.

Short Answer

Use the diagram to answer the questions.

The Greenhouse Effect



17. Name two gases that would be included in the label “greenhouse gases” in the figure.
18. What would Earth be like if the greenhouse effect did not exist?
29. What does the theory of global warming state is happening to the greenhouse effect?
20. What is one source on Earth of carbon dioxide?
21. Predict one possible effect of an increase in Earth’s temperature as a result of a stronger greenhouse effect.
22. What is the original source of the heat that is trapped by the greenhouse effect?

The Greenhouse Effect and Global Warming

Answer Section

MULTIPLE CHOICE

1. ANS: A Identify and describe outdoor and indoor air pollutants.
2. ANS: B Explain the importance of ozone in the upper atmosphere
3. ANS: A Describe the greenhouse effect and explain how it affects climate.
4. ANS: B Describe the greenhouse effect and explain how it affects climate.
5. ANS: C Explain the importance of ozone in the upper atmosphere.
6. ANS: C Describe ways that technology can help control air pollution.
7. ANS: A Explain how the sun provides energy and describe ways to collect this energy.
8. ANS: B
9. ANS: B
10. ANS: B
11. ANS: A

MODIFIED TRUE/FALSE

12. ANS: F, increase Describe the greenhouse effect and explain how it affects climate.
13. ANS: F, atmosphere [or air] Describe the greenhouse effect and explain how it affects climate.

COMPLETION

14. ANS: ultraviolet Explain the importance of ozone in the upper atmosphere.
15. ANS: greenhouse effect Describe the greenhouse effect and explain how it affects climate.
16. ANS: computer models Describe the greenhouse effect and explain how it affects climate.

SHORT ANSWER

17. ANS:
water vapor and carbon dioxide Describe the greenhouse effect and explain how it affects climate.
18. ANS:
Earth would be much colder without the greenhouse effect to trap heat near Earth's surface.
Describe the greenhouse effect and explain how it affects climate.
19. ANS:
The theory of global warming states that the increase in carbon dioxide in the atmosphere is causing the greenhouse effect to grow stronger. As more heat is trapped near Earth's surface, Earth's average temperature is rising.
Describe the greenhouse effect and explain how it affects climate.
20. ANS:
Industries and power plants that burn fossil fuels such as coal and oil
Describe the greenhouse effect and explain how it affects climate.
21. ANS:
Possible answers include melting of the Antarctic ice cap, a rise in ocean levels, changes in climate patterns, more severe storms, and changes in where crops are grown.
Describe the greenhouse effect and explain how it affects climate.
22. ANS:

sunlight (or energy from the sun)

Describe the greenhouse effect and explain how it affects climate.